On the Role of Group Size in Social Dilemmas

(Article begins on next page)

19 April 2024

Abstract

Reconciling individual choices with public interest is central to human society: from market competition to environment protection, there are many situations that can be modelled by means of social dilemmas. This paper reviews the psychological literature contributions investigating the specific impact of group size on cooperation in social dilemmas. Moreover, we present an overview of the main – sometimes conflicting – explanations proposed in the literature. After discussing the possible limitations of this review we discuss the implications and directions for future research.

Conciliare le scelte individuali con l'interesse pubblico è uno snodo centrale all'interno della società: dalla competizione nel mercato alla salvaguardia dell'ambiente, vi sono molte situazioni che possono essere modellizzate come dilemmi sociali. Questo articolo propone un'analisi della letteratura psicologica che ha studiato l'impatto specifico della numerosità del gruppo nei dilemmi sociali. Inoltre, presenteremo una panoramica delle principali, spesso contrastanti, spiegazioni proposte in letteratura. Dopo aver discusso i possibili limiti della rassegna ne verranno presentate le implicazioni e direzioni per la ricerca futura.

Keywords: cooperation, social dilemmas, group size, public goods.

Parole chiave: cooperazione, dilemmi sociali, dimensione del gruppo, beni comuni.

1. Introduction

Most human decisions do not occur in a social vacuum (Tajfel, 1982). On the contrary, there are many situations in which it is clear that individual choices are strongly influenced by the presence of others (e.g., Markus, 1978; Chekroun & Brauer, 2002), even if others are merely present and the situation does not involve a direct social interaction (e.g., Platania & Moran, 1999). The impact of others on individuals' performance has inspired some interesting contributions, which social psychology has provided since the origin of the discipline (see, e.g., Triplett, 1898). Although these seminal contributions showed how the presence of others leads to powerful effects, they do not agree upon the kind of effect. On the one hand, in one of the first seminal social psychological experiments, Triplett (1898) showed that individuals working alone had a worse result when compared with those dealing with the same task as a group. This study offers an example of the *social facilitation* effect, in which others are considered as incentives to improve individual performance. On the other hand, Ringelmann's studies (1913) became the basis of the *social loafing* perspective, in which the presence of others represents a limitation on individuals' decision-making. Even if the primary aim of these studies was the evaluation of individual performance in terms of facilitation and inhibition, they provided an original frame for comprehension of the role of the group and its effects.

In this review, we provide a closer and articulated perspective of some cooperative decision-making situations. Our analysis focuses on the specific role played by group size in determining the amount of cooperation in social dilemmas.

In fact, although variables such as communication (Balliet, 2010), reward and punishment (Balliet, Mulder & Van Lange, 2011), social value orientation (Balliet, Parks & Joireman, 2009), ingroup favouritism (Balliet, Wu & De Dreu, 2014) and trust (Balliet & Van Lange, 2013) have been widely analysed, less has been done when considering group size. To the best of our knowledge, the present review represents the first effort in literature trying to analyse the influence of group size on cooperation and represents an attempt to summarize the main psychological perspectives that have been proposed through the years to account for the effect of this structural dimension on cooperation.

In social dilemmas, it is clear that the number of people involved in the situation plays a significant role, due to their intrinsic interactive nature. As widely sustained in psychology, processes that operate in dyads are fundamentally different from those underlying larger groups (Moreland, 2010). Although there is a common agreement on the recognition of the influence of group size on the individual decision to cooperate in social dilemmas (Kollock, 1998), opinions on the direction of this relationship are not univocal (Schroeder, 1995). Hence, which cognitive processes can be influenced by fluctuation in the dimension of the group? How will these processes result in higher or lower cooperation? The aim of this paper is to explore these questions, taking into account both the social psychology literature on the role of a group and reviewing social dilemma experiments that specifically investigated the role of group size.

As the literature reveals both positive and negative effects of this structural variable, we will review the theoretical perspectives accounting for these contradictory findings by considering the type of social dilemma, the psychological

dimension related to the positive effects of group size, and the psychological dimensions examined to address its negative effects.

In the first part of this review, we present a definition of social dilemmas and distinguish *public goods dilemmas* from *commons* ones. In particular, we will focus on the difference between continuous public goods and step-level ones. This difference will be essential in order to analyse how group size influences cooperation depending on the kind of public good that is considered. Then, after mentioning group size among the different structural solutions to social dilemmas proposed in the literature, we review the main psychological dimensions addressed in literature to explain both its positive and negative effects, exploring some directions for further research.

2. Social dilemmas

Conflicts of individual and collective interests are commonly studied in psychology using experimental games (see Komorita & Parks, 1996, for a review) and they are generically known in literature as social dilemmas (Dawes, 1980). These situations of mixed-motive interaction are intriguing from a psychological point of view because of the possibility they provide to investigate the basis of human cooperation. Social dilemmas caught the interest of many different disciplines and this research can make use of heterogeneous contributions: sociology (Kollock, 1998), economics (Ostrom, 1998), evolutionary biology (Nowak, 2006) and sociophysics (Nagurney, 2010) are just a few examples of these different perspectives. One of the most challenging questions for psychologists interested in

studying social dilemmas is to understand how cooperation can be promoted (for a review see Van Lange, Joireman, Parks & Van Dijk, 2013).

A mixed-motive interaction can be explained by referring to the dynamics underlying choices in the two-person prisoner's dilemma. In this context defection represents the dominant strategy, ensuring the best outcome to the decision maker regardless of the other's choice. However, the correspondent outcome obtained when both individuals defect is lower than if they had both cooperated (dominated equilibrium) (Kollock, 1998). Although the two-person prisoner's dilemma has been widely investigated, most real social interactions take place with more than two individuals. These situations are identified as *social dilemmas* (Van Lange, Joireman, Parks & Van Dijk, 2013) and are characterized by the presence of a dominant strategy and a dominated equilibrium (Dawes, 1980). In these situations, people are highly incentivized to make the choice that leads every person to achieve the highest payoff, but if the same reasoning is followed by all members of the group, it will result in an outcome that is worse for all the group (Dawes & Messick, 2000). Public goods and commons dilemmas are the most typical social dilemmas. Let us examine them separately.

2.1 Public goods dilemmas

In public goods dilemmas, the conflict lies in the possibility for each participant to benefit from a common good built from the efforts of the group members, regardless of their contribution to it. The tempting nature of this action is linked to two intrinsic properties of a public good discussed in Kollock, 1998. First,

non-excludability: once a public good is accessible, no one can be prohibited from enjoying it. In other words, there is the temptation to maximize the personal outcome, giving no contribution and taking advantage of the good. The core of the problem is that if no individuals intend to contribute, the public good cannot be provided at all. Literature on social dilemmas refers to these individuals as free-riders (Hardin, 1968). The lack of cooperation in free-riding strategy could lie in different motivations, such as the desire to keep the best possible outcome, or even the fear of being a sucker (the belief that other participants will not cooperate, taking advantage from his contribution) (Kerr, 1983).

Second, public goods *non-rivality*: the amount of use of the good by an individual does not affect others' possibility to use the resource as well. In other words, once the good is provided, individuals can have access to the same amount of the good.

The provision of public transportation is a good example of the tempting nature of the free-riding choice in public goods dilemmas. From a utilitarian perspective, enjoying the use of public transport without paying for tickets leads to the double advantage of saving money and benefiting from the service. Nevertheless, the spread of this behavior among a higher proportion of citizens results in a dramatic reduction of the service quality for the entire collective. The provision of the public goods can be ruled in two main ways, which directly affect the equilibrium of the game (Abele, Stasser & Chartier, 2010): they can be *step-level* or *continuous*. In step-level public goods, there is a set cut-point of contributions that needs to be reached in order to provide the collective good. If this minimum is not attained, the resource will not be available and all contributions will be lost. Conversely, in

continuous public goods no set amounts of contributions are required to provide the resource. Komorita and Parks (1996) provide two examples of step-level and continuous public goods we can face in everyday life. In the first case, consider the building of a bridge. Indeed, its full realization is possible only if the amount collected by taxpayers reaches a threshold, since a bridge represents a discrete entity that has to be complete in order to fulfil its main function. By contrast, an example of a continuous public good is given by the service provided by a non-profit association. In this case, the services will be provided anyway, but their quality will be proportional to the contributions.

2.2 Commons dilemmas

Commons dilemmas represent the opposite situation, as individuals have the temptation to gain a positive profit in the short-term, but if all individuals behave selfishly this will lead to a collective loss in the long-term. The most famous metaphor is the "tragedy of commons", described by Hardin (1968): imagine there are *n*-herders sharing a pasture in which their cows graze. For each herder it is in his own personal interest to lead as many cows as possible onto the land; yet, if all the herders behave according to this logic, the common pool will be exploited, leading to the collective disaster. As public goods, commons dilemmas are *non-excludable*, but the main difference is that they are *rival*. This characteristic refers to the subtractability of benefits: individuals can harvest their own portion of the common source depending on the carrying capacity of the resource (Kollock, 1998).

An example of commons dilemma is the Braess paradox (Braess, 1968; Arnott & Small, 1994). It specifically regards transportation, since the common resource is a route of a traffic network. The Braess paradox is known as the counter-intuitive phenomenon in which adding a new route in a traffic network increases the traffic instead of reducing it (Braess, 1968; Morgan, Orzen & Sefton, 2009).

In a typical Braess paradox-based game, participants take the role of commuters aiming at minimizing their travel time (Rapaport, Kugler, Dugar & Gisches, 2009; Gisches & Rapaport, 2012; Dal Forno & Merlone, 2013).

In this section, we presented a definition of social dilemmas introducing public goods and commons dilemmas. In the next section, we will discuss the structural solutions of social dilemmas, underlining the crucial role played by group size on these dynamics.

3. Structural solutions to social dilemmas: the role of group size

In social dilemmas, structural solutions are changes in the rules that can influence cooperation rates (Kollock, 1998). Among the several changes proposed in the literature, we list *iteration and identifiability*, *payoff structure*, *boundaries*, *sanctions* and *group size*. In the following, we will focus our attention on group size for the following reasons.

First, n-person interactions are complex, making cooperation more difficult to establish (Thompson, 2001). In fact, compared with dyadic mixed motives interactions, in multi-person social dilemmas defection becomes less costly when participants grow numerically and individuals are aware that costs are shared and

distributed among them. Moreover, coordination becomes harder to reach and individuals have less control over the situation. Finally, social dilemmas are riskier in comparison with two-person interactions because of the higher cost associated with others' defection.

Second, experimental evidences in literature present contrasting findings. Although it is commonly recognized that group size affects cooperation in several ways, there is a lack of a strong and straightforward explanation accounting for these mechanisms (Zelmer, 2003). Moreover, although there is a wide common agreement on the recognition of the influence of group size on the individual decision to cooperate in social dilemmas (Kollock, 1998), opinions on the direction of this relationship are not univocal (Schroeder, 1995). Recent findings (Barcelo & Capraro, 2015) show how larger groups increase cooperation in a continuous public goods game while the opposite effect is observed in an *n*-person prisoner's dilemma. The same contrasting findings can be found in Bonacich, Shure, Kahan and Meeker (1976), in Shank and colleagues (2015) and Yamagishi (1990). Contrasting findings are also present among results across different disciplines and the Braess paradox represents a good example (see Rapaport, Mak & Zwick, 2006; Nagurney, 2010). Table 1 reports a list of studies considering group size in social dilemmas in chronological order. The studies were selected by considering the ones that specifically investigated or manipulated the effect of group size in social dilemmas. With a few exceptions, all of them consider either public goods dilemmas or common dilemmas. The studies we consider are either experiments (E) or meta-analysis (M) as reported in the fifth column of Table 1. The table helps to provide a general summary of inconsistent findings of studies accounting for group dimension

in social dilemmas. Finally, the signs reported in the last column summarize how group size affects cooperation rates.

Third, solving social dilemmas in the real world requires flexible interventions to account for problems that are specifically related to different group dimensions (e.g., management of local, national and global resources). Finally, there is a lack of a comprehensive theoretical framework providing a model for understanding the interplay between the group dimension and the social dilemma situation. For example, Kelley and Thibaut's Interdependence theory (1978) represents the most established conceptual framework through which years of psychological research contributed to the understanding of cooperation in mixed motive interdependence contexts. Although this approach has allowed researchers to highlight the role of psychological variables as personality differences (Messick & McClintock, 1968) and relationship-specific motives (Rusbult & Van Lange, 2003), according to Van Lange and Rusbult (2012), its central limitation is that its assumptions can rarely be extended to non-dyadic interactions.

In this section, we presented the structural solutions to social dilemmas focusing on the critical role of group size on cooperation. In the next sections, we present the psychological aspects addressed to explain the negative and positive effects of group size.

4. The negative effects of group size

As discussed above, a central feature of social dilemmas is the presence of several individuals. According to Dawes (1980) and Brett (2007), competitive

dynamics are more difficult to control when several people are involved. The literature presents many studies showing that an increase of group size has deleterious effects on cooperation (e.g., Messick & McLelland, 1983b; Isaac & Walker, 1988; Kerr, 1989; Barcelo & Capraro, 2015).

This negative impact of the presence of others on social decision-making has been widely explored from a social-psychological perspective. For example, according to Brewer and Kramer (1986) and Komorita and Parks (1996), the presence of large groups may have deleterious effects in such situations for three main reasons.

First, individuals have *concern for reciprocal behavior*. As research on cooperation in the two-person prisoner's dilemma game demonstrates (Nowak, 2006), strategies based on strict reciprocity such as tit-for-tat are the most effective in promoting cooperation. In tit-for-tat, cooperation is always played as first choice and every further move reflects the direct reciprocation of the partner's choices (Axelrod, 1984). As stated in Wilson (1971, p.187) *"when rewards are applied consistently and promptly to desired behavior and punishments to undesired behavior, behavior can be controlled very effectively"*. This represents a crucial aspect in the case of larger numbers of individuals interacting together. In fact, the increased possibility of defection of the members is associated with the diminished control over direct reciprocation, so that the possibility to influence others' behavior becomes unlikely.

The second reason is *diffusion of responsibility*. In the seminal experiment of Darley and Latane (1968), the number of bystanders present in the experimental setting was inversely related to participants' helping behavior. The explanation of the so-called bystander effect based on diffusion of responsibility reflects the idea that,

in the presence of others, individuals feel less personally responsible for what happens in the social environment because others are called to intervene too. In terms of collective performance in social dilemmas, individuals may act under a similar logic, considering their contributions less critical and resulting in a more selfish behavior (Komorita & Parks, 1996).

The third antecedent to the noxious effect of group size on cooperation can be represented by the *de-individuation* of participants. Studies on crowds claim how individuals are more likely to feel anonymous and de-individuated when immersed in situations together with a huge number of people, intensifying substantial consequences on social behavior, even resulting in performing anti-social and aggressive actions (Zimbardo, 1970). In terms of social dilemmas, this state of mind could undermine one of the main elements that discourage people from free-riding: the undertaking of the social cost of one's own actions and the consequent social shame associated with the defection. Indeed, in large groups it is almost impossible to understand who is defecting and people are thus de-individuated (Hamburger, Guyer & Fox, 1975).

In this section, we outlined the literature on the negative effects of group size on cooperation presenting concern for reciprocal behavior, diffusion of responsibility and de-individuation processes as the main psychological responsible mechanisms identified to explain these findings. However, as we will see in the next section, under specific conditions large groups may also have a positive effect on cooperation.

5. The positive effects of group size

The contrasting nature of group size has been revealed in some laboratory experiments, when considering social identity, communication and perceived self-efficacy.

A study conducted by Brewer and Kramer (1986) examined the role of group size, social identity and decision framing. The researchers used groups of seven and 31 participants and used both a public goods and a commons dilemma. The main finding was that the negative effect of group size was related to cooperation only when the problem was presented as a public goods dilemma compared with the condition in which it was framed as a commons. In particular, these authors did not find a negative effect of the dimension of the group when the problem was framed as a commons dilemma and thus cooperation increased in larger groups when *social identity* was salient. According to their discussion, in commons dilemmas the presence of large groups makes more salient the collective risk and losses of the harvesting behavior, whereas in public goods an effect of diffusion of responsibility is more likely to occur (Brewer & Kramer, 1986).

Another factor that seems to elicit cooperation with the increase of group size is *communication*. Recently, in a meta-analysis on the role of communication in social dilemmas, Balliet (2010) focused on the effect of different types of communication on cooperation. According to the meta-analysis, when considering group size as a moderator of the relationship between communication and cooperation, groups of larger sizes increase cooperation rates (2010). Therefore, when individuals are given the possibility to communicate, even before or during the

deliberation, larger groups are more cooperative than smaller ones. In this work, the author proposes two different reasons to account for this phenomenon. First, it is possible that engaging in a conversation on the ongoing dynamics increases the sense of self-efficacy and the perceived sense of being critical for the group even in large groups (Kerr, 1989). This idea is also endorsed by evolutionary theory, according to which large groups may enhance distal mechanisms as factors related to human evolution (Gintis, Smith, & Bowles, 2001). In fact, the act of communication can be seen under the lens of costly signalling theory, which considers altruistic acts as a means of affirming one's own social status or to communicate to others information about the self in order to be considered a potential cooperative. By contrast, a previous study on communication and group size conducted by Liebrand (1984) showed no differences between cooperation rates among the conditions.

The third crucial dimension considered in literature in relation to positive effects of group size in social dilemmas is *self-efficacy*. In a study conducted by Sanna (1992), the author tried to integrate the social loafing and social facilitation paradigms through a model accounting for self-efficacy (Bandura, 1977). According to this model, self-efficacy can explain the different pattern of behaviors shown in large groups. In particular, it supports the idea that individuals experiencing high self-efficacy in a group promote social facilitation, whereas low self-efficacy increases social loafing processes, because of perceiving one's own contribution as less critical for the overall result. Kerr (1989) demonstrated that in social dilemmas the perception of self-efficacy decreases in large groups, even if the payoff structure actually shows an opposite trend. In other words, individuals tend to have an

"illusion of efficacy" in small groups, regardless of the actual interdependence situation.

In the social dilemmas literature, we can find several studies in which increasing self-efficacy in larger groups leads to positive effects on cooperation (e.g., Erev & Rapoport, 1990; De Cremer & Van Dijk, 2002). Moreover, in the studies showing a positive impact of group size on cooperation, together with group identity and communication, self-efficacy has been considered to play a crucial role (Balliet, 2010; Brewer & Kramer, 1986). Following Messick and Brewer's words on social identity (1983c, pp.28): *"when individuals feel that their actions are representative of some larger social entity, the perceived impact of those actions is magnified and the individual's sense of personal responsibility for collective outcomes enhanced"*. Moreover, considering the relation between group size and communication, Balliet (2010, p. 53) hypothesizes that this factor may enhance a feeling of self-efficacy and "*then an individual may sense that their contribution is critical to attaining the public good"*.

In this section, we presented some crucial psychological dimensions considered when the effect of group size on cooperation is positive. In such situations, communication, social identity and self-efficacy seem to play a key role in promoting the positive relation between group size and cooperation.

6. Conclusions

Contrasting findings emerged from our review of the experimental evidences investigating the role of group size in social dilemmas. In several studies, the number

of participants seems to have a negative impact on cooperation rates (e.g., Messick &

McLelland 1983b; Hamburger, Guyer & Fox, 1975; Bixenstine et al., 1966).

However, the literature also presents studies in which group size has no effect

(Liebrand, 1984) and, more surprisingly, a positive one on cooperation (Brewer &

Kramer, 1986; Bonacich, Shure, Kohan & Meeker, 1976). From our perspective, a

review of group size has both theoretical and practical implications.

From a theoretical point of view, although social dilemmas are rooted in social

interaction involving more than a dyad, there is a lack of theoretical framework

accounting for group dimension. Our review aims at contributing to literature as a

starting point for developing new theoretical frameworks that can account for the

different trends presented in the literature and to explain the role of the psychological

mechanisms related to group size. Social psychological explanations may be useful

not only to understand findings from laboratory experiments, but also to provide an

interpretation of the insights from other disciplines as sociophysics (e.g., Nagurney,

2010). The main practical implication is related to design interventions to solve

social dilemmas in the real world. In this case, understanding the risks and the

strengths of particular group configurations may lead to more efficient solutions.

Moreover, the review provides a basis for future experimental studies aiming at

understanding some specific psychological mechanisms related to group size, or the

relation among them.

Although each dimension mentioned in the review may play a crucial role in

understanding the role of group size, our work presents some limits. First, the

presence of ambiguous results can be attributed to methodological problems that

arise within the study of the specific effect of group size rather than psychological

factors. The main question lies in the difficulty in isolating this variable in a social dilemma (Colman, 1995). Second, we focused on studies that present different group sizes. For this reason, different psychological processes could underlie them, besides the difficulties in making proper comparisons.

Since most of the dilemmas that individuals face in everyday life take place on a large-scale (e.g., pro-environmental behavior), further research on the role of group size deserves to be done to elaborate effective strategies for promoting a sense of self-responsibility and, thus, cooperation. In particular, both theoretical advances and further empirical research are needed, holding together results of different disciplines and integrating the several psychosocial dynamics involved in this context.

References

Abele, S., Stasser, G., & Chartier, C. (2010). Conflict and coordination in the provision of public goods: A conceptual analysis of continuous and step-level games. *Personality and Social Psychology Review, 14*(4), 385-401. http://dx.doi.org/10.1177/1088868310368535.

Arnott, R., & Small, K. A. (1994). The economics of traffic congestion. *American Scientist, 82*, 446–455.

Alxerod, R. (1984). *The evolution of cooperation*. New York, NY: Basic Books.

Balliet, D. (2010). Communication and cooperation in social dilemmas: A meta-analytic review. *Journal of Conflict Resolution, 54*(1), 39-57. http://dx.doi.org/10.1177/0022002709352443.

Balliet, D., & Mulder, L. B., & Van Lange, P. A. M. (2011). Reward, punishment, and cooperation: A meta-analysis. *Psychological Bulletin, 137,* 594-614. http://dx.doi.org/10.1037/a0023489.

Balliet, D., Parks, C., & Joireman, J. (2009). Social value orientation and cooperation in social dilemmas: A meta-analysis. *Group Processes and Intergroup Relations, 12*, 533-547. http://dx.doi.org/10.1177/1368430209105040.

Balliet, D., & Van Lange, P. A. M. (2013). Trust, conflict, and cooperation: A meta-analysis. *Psychological Bulletin, 139,* 1090-1112. http://dx.doi.org/10.1037/a0030939.

Balliet, D., Wu, J., & De Dreu, C. (2014). Ingroup favoritism in cooperation: A meta-analysis. *Psychological Bulletin, 140*(6), 1556-1581. http://dx.doi.org/10.1037/a0037737.

Bandura, A. (1977). Self-efficacy theory: Toward a unifying theory of behavioral change. *Psychological Review, 84,* 191-215. http://dx.doi.org/10.1037/0033-295X.84.2.191.

Barcelo, H., & Capraro, V. (2015). Group size effect on cooperation in one-shot social dilemmas. *Scientific Reports, 5,* 1-8. http://dx.doi.org/10.1038/srep07937.

Bixenstine, V. E., Levitt, C. A., & Wilson, K. B. (1966). Collaboration among six persons in a prisoner's dilemma game. *Journal of Conflict Resolution, 10*, 488-496.

Bonacich, P., Shure, G. H., Kahan, J. P., & Meeker, R. J. (1976). Cooperation and group size in the n-person prisoner's dilemma. *Journal of Conflict Resolution, 20*, 687-705. http://dx.doi.org/10.1177/002200277602000406.

Braess, D. (1968). Uber ein Paradoxon der Verkehrsplanung. *Unternehmensforschung, 12*, 258–268. http://dx.doi.org/10.1007/BF01918335.

Brett, J. (2007). *Negotiating globally: How to negotiate deals, resolve disputes, and make decisions across cultural boundaries*. San Francisco, CA: John Wiley & Sons.

Brewer, M. B., & Kramer, R. M. (1986). Choice behavior in social dilemmas. effects of social identity, group size, and decision framing. *Journal of Personality and Social Psychology, 50*(3), 543-549. http://dx.doi.org/10.1037/0022-3514.50.3.543.

Carpenter, J. P. (2007). Punishing free-riders: How group size affects mutual monitoring and the provision of public goods. *Games and Economic Behavior*, *60*(1), 31-51. http://dx.doi.org/10.1016/j.geb.2006.08.011.

Chekroun, P., & Brauer, M. (2002). The bystander effect and social control behavior: the effect of the presence of others on people's reactions to norm violations. *European Journal of Social Psychology, 32*, 853-867. http://dx.doi.org/10.1002/ejsp.126.

Colman, A. M. (1995). *Game Theory and its Applications in the Social and Biological Sciences*. Oxford, UK: Butterworth Heinemann.

Dal Forno, A., & Merlone, U. (2013). Replicating human interaction in Braess paradox. In *Proceedings of the 2013 Winter Simulation Conference: Simulation: Making Decisions in a Complex World* (pp. 1754-1765). IEEE Press.

Darley, J. M., & Latane, B. (1968). Bystander intervention in emergencies: Diffusion of responsibility. *Journal of Personality and Social Psychology, 8,* 377-383. http://dx.doi.org/10.1037/h0025589.

Dawes, R. M. (1980). Social dilemmas. *Annual Review of Psychology, 31*, 169–193. http://dx.doi.org/10.1146/annurev.ps.31.020180.001125.

Dawes, R. M., & Messick, D. M. (2000). Social Dilemmas. *International Journal of Psychology, 35*, 111-116. http://dx.doi.org/10.1080/002075900399402.

De Cremer, D., & van Dijk, E. (2002). Perceived criticality and contributions in public good dilemmas: A matter of feeling responsible to all?. *Group Processes & Intergroup Relations, 5*(4), 319-332. http://dx.doi.org/10.1177/1368430202005004004.

De Cremer, D., & Leonardelli, G. J. (2003). Cooperation in social dilemmas and the need to belong: The moderating effect of group size. *Group Dynamics: Theory, Research, and Practice*, *7*(2), 168-176. http://dx.doi.org/10.1037/1089-2699.7.2.168.

De Kwaadsteniet, E. W., van Dijk, E., Wit, A., & De Cremer, D. (2008). How Many of Us Are There?: Group Size Uncertainty and Social Value Orientations in Common Resource Dilemmas. *Group Processes & Intergroup Relations, 11*(3), 387-399. http://dx.doi.org/10.1177/1368430208090649.

Fox, J., & Guyer, M. (1978). "Public" choice and cooperation in n-person prisoner's dilemma. *Journal of Conflict Resolution, 22*(3), 469-481. http://dx.doi.org/10.1177/002200277802200307.

Gisches, E. J., & Rapaport, A. (2012). Degrading network capacity may improve performance: private versus public monitoring in the Braess Paradox. *Theory and Decision*, *73*(2), 267-293. http://dx.doi.org/10.1007/s11238-010-9237-0.

Gintis, H., Smith, E. A., & Bowles, S. (2001). Costly signaling and cooperation. *Journal of Theoretical Biology, 213*, 103–119. http://dx.doi.org/10.1006/jtbi.2001.2406.

Hamburger, H., Guyer, M. and Fox, J. (1975). Group size and cooperation. *Journal of Conflict Resolution, 19*, 503-531. http://dx.doi.org/10.1177/002200277501900307.

Hardin, G. (1968). The tragedy of the commons. *Science, 162*, 1243-1248. http://dx.doi.org/10.1126/science.162.3859.1243.

Hardin, R. (2005). The Free Rider Problem. In E. N. Zalta (Ed.) *The Stanford Encyclopedia of Philosophy* (Spring 2013 ed.). Retrieved from http://plato.stanford.edu/archives/spr2013/entries/free-rider/.

Isaac, R. M., Walker, J. M., & Williams, A. W. (1994). Group size and the voluntary provision of public goods: experimental evidence utilizing large groups. *Journal of Public Economics*, *54*(1), 1-36. http://dx.doi.org/ 10.1016/0047-2727(94)90068-X.

Isaac, R. M., & Walker, J. M. (1988). Group size effects in public goods provision: The voluntary contributions mechanism. *The Quarterly Journal of Economics*, *53*, 179-199.

Kelley, H. H., & Thibaut, J. W. (1978). *Interpersonal relations: A theory of interdependence.* New York, NY: Wiley.

Kerr, N. L. (1983). Motivation losses in small groups: A social dilemma analysis. *Journal of Personality and Social Psychology, 45*(4), 819-828. http://dx.doi.org/10.1037/0022-3514.45.4.819.

Kerr, N. L. (1989). Illusions of efficacy: The effects of group size on perceived efficacy in social dilemmas. *Journal of Experimental Social Psychology, 25*(4), 287-313. http://dx.doi.org/10.1016/0022-1031(89)90024-3.

Kollock, P. (1998). Social dilemmas: The anatomy of cooperation. *Annual Review of Sociology, 24*, 183–214.

Komorita, S. S., & Parks, C. D. (1996). *Social dilemmas*. Boulder, CO: Westview Press.

Liebrand, W. B. G. (1984). The effects of social motives, communication and group size on behavior in an n-person multi-stage mixed-motive game. *European Journal of Social Psychology, 14*, 239-264. http://dx.doi.org/10.1002/ejsp.2420140302.

Markus, H. (1978). The Effect of Mere Presence on Social Facilitation: An Unobtrusive Test. *Journal of Experimental Social Psychology, 14*, 389-397. http://dx.doi.org/10.1016/0022-1031(78)90034-3.

Marwell, G., & Schmitt, D. R. (1972). Cooperation in a three-person Prisoner's Dilemma. *Journal of Personality and Social Psychology, 21*(3), 376-383. http://dx.doi.org/10.1037/h0032319.

Messick, D. M., Wilke, H., Brewer, M. B., Kramer, R. M., Zemke, P. E., & Lui, L. (1983a). Individual adaptations and structural change as solutions to social dilemmas. *Journal of Personality and Social Psychology, 44*(2), 294. http://dx.doi.org/10.1037/0022-3514.44.2.294.

Messick, D. M., & McClelland, C. L. (1983b). Social traps and temporal traps. *Personality and Social Psychology Bulletin, 9*, 105-110. http://dx.doi.org/10.1177/0146167283091015.

Messick, D. M., & Brewer, M. B. (1983c). Solving social dilemmas. In L. Wheeler, & P.R. Shaver (Eds.) *Review of Personality and Social Psychology (Vol. 4)* (pp. 11-44). Beverly Hills: SAGE Publications.

Messick, D. M., & McClintock, G. (1968). Motivational bases of choice in experimental games. *Journal of Experimental Social Psychology*, *4*, 1-25. http://dx.doi.org/10.1016/0022-1031(68)90046-2.

Moreland, R. L. (2010). Are dyads really groups?. *Small Group Research, 20*, 1-17. http://dx.doi.org/ 0.1177/1046496409358618.

Nagurney, A. (2010). The negation of the Braess paradox as demand increases: The wisdom of crowds in transportation networks. *Europhysics Letters, 91*(4), 1-5. http://dx.doi.org/10.1209/0295-5075/91/48002.

Nosenzo D, Quercia, S., & Sefton, M. (2013). Cooperation in small groups: The effect of group size. *Experimental Economics, 18*, 4-14. http://dx.doi.org/10.1007/s10683-013-9382-8.

Nowak, M. A. (2006). Five rules for the evolution of cooperation. *Science, 314*(5805), 1560-1563. http://dx.doi.org/10.1126/science.1133755.

Ostrom, E. (1998). A behavioral approach to the rational choice theory of collective action: presidential address, American Political Science Association, 1997. *American Political Science Review, 92*(1), 1–22. http://dx.doi.org/10.2307/2585925.

Platania, J., & Moran, G. P. (2001). Social Facilitation as a Function of the Mere Presence of Others. *The Journal of Social Psychology, 141*, 190-197. http://dx.doi.org/10.1080/00224540109600546.

Rapoport, A., Mak, V., & Zwick, R. (2006). Navigating congested networks with variable demand: experimental evidence. *Journal of Economic Psychology, 27*(5), 648–666. http://dx.doi.org/10.1016/j.joep.2006.06.001.

Rapoport, A., Kugler, T., Dugar, S., & Gisches, E. J. (2009). Choice of routes in congested traffic networks: Experimental tests of the Braess Paradox. *Games and Economic Behavior, 65*(2), 538–571. http://dx.doi.org/10.1016/j.geb.2008.02.007.

Ringelmann, M. (1913). Research on animate sources of power: The work of man. *Annales de l'Instuit National Agronomique, 12*, 1-40.

Rusbult, C. E., & Van Lange, P. A. (2003). Interdependence, interaction, and relationships. *Annual Review of Psychology, 54*(1), 351-375.

Sanna, L. J. (1992). Self-efficacy theory: Implications for social facilitation and social loafing. *Journal of Personality and Social Psychology, 62*, 774-786. http://dx.doi.org/10.1037/0022-3514.62.5.774.

Schroeder, D. A. (1995). *Social Dilemmas: perspectives on individuals and groups*. Westport, CT: Praeger.

Seijts, G. H., & Latham, G. P. (2000). The effects of goal setting and group size on performance in a social dilemma. *Canadian Journal of Behavioural Science/Revue canadienne des sciences du comportement, 32*(2), 104-116. http://dx.doi.org/10.1037/h0087105.

Seijts, G. H., Latham, G. P., & Whyte, G. (2000). Effect of self-and group efficacy on group performance in a mixed-motive situation. *Human Performance*, *13*(3), 279-298. http://dx.doi.org/10.1207/S15327043HUP1303_3.

Shank, D. B., Kashima, Y., Saber, S., Gale, T., & Kirley, M. (2015). Dilemma of Dilemmas: How Collective and Individual Perspectives Can Clarify the Size Dilemma in Voluntary Linear Public Goods Dilemmas. *PloS one*, *10*(3), 1-19. http://dx.doi.org/10.1371/journal.pone.0120379.

Tajfel, H. (1982). Social psychology of intergroup relations. *Annual review of psychology, 33*(1), 1-39.

Thompson, L. (2001). *The mind and heart of the negotiator second edition*. Upper Saddle River NJ: Prentice-Hall.

Triplett, N. (1898). The dynamogenic factors in pacemaking and competition. *American Journal of Psychology, 9,* 507-533. http://dx.doi.org/10.2307/1412188.

Van Lange, P. A. M, Joireman, J., Parks, C. D., & van Dijk, E. (2013). The psychology of social dilemmas: A review. *Organizational Behavior and Human Decision Processes 120,* 125–141. http://dx.doi.org/10.1016/j.obhdp.2012.11.003.

Van Lange, P. A. M., & Rusbult, C. E. (2012). Interdependence theory. In P. A. M. Van Lange, A. Kruglansky, & E. T. Higgins (Eds.), *Handbook of Theories of Social Psychology: Volume Two* (pp. 251-273). SAGE Publications.

Wilson, W. (1971). Reciprocation and other techniques for inducing cooperation in the prisoner's dilemma. *Journal of Conflict Resolution, 15*, 167-196. http://dx.doi.org/10.1177/002200277101500205.

Yamagishi, T. (1986). The provision of a sanctioning system as a public good. *Journal of Personality and Social Psychology, 51*(1), 110-116. http://dx.doi.org/10.1037/0022-3514.51.1.110.

Yamagishi, T. (1990). Factors mediating residual effects of group size in social dilemmas. *Japanese Journal of Psychology, 61*(3):162–9. http://dx.doi.org/10.4992/jjpsy.61.162.

Zelmer J. (2003). Linear public goods experiments: A meta-analysis. *Experimental Economics. 6*(3), 299–310. http://dx.doi.org/10.1023/A:1026277420119.

Zimbardo, P. G. (1970). The human choice: Individuation, reason and order vs deindividuation, impulse, and chaos. In W. J. Arnold & D. Levine (Eds.), *1969*

Nebraska Symposium on Motivation (237-307). Lincoln: University of Nebraska Press.